

NATIONAL R&D PERFORMANCE PATTERNS—

BY SECTOR

OVERVIEW

The sectoral shares of U.S. R&D performance, measured in terms of expenditures, have shifted significantly since the early 1980s. In 1980, industry—including industry-administered Federally Funded Research and Development Centers (FFRDCs)—performed 70.6 percent of the Nation's R&D; the academic sector (including academically administered FFRDCs) accounted for 13.6 percent; the Federal Government, 12.4 percent; and the nonprofit sector (including nonprofit-administered FFRDCs), 3.4 percent. As industry's defense-related R&D efforts accelerated in the early eighties, its share of the performance total rose to 73.7 percent in 1985.

From 1985–94, R&D performance grew by only 1.1 percent per year in real terms for all sectors combined. This growth was not evenly balanced across sectors, however. R&D performance at universities and colleges (including their FFRDCs) grew by 4.3 percent per year in real terms, compared with only 0.7-percent growth for industry, a decline of 0.7 percent per year for Federal intramural performance, and growth of 3.0 percent per year for nonprofit organizations (including their FFRDCs).

The period from 1994–98 witnessed dramatic changes in these growth rates, according to preliminary estimates. Total R&D performance, in real terms, averaged 4.7 percent growth per year, which was substantially higher than in the earlier sluggish period. Yet R&D performance at universities and colleges (including their FFRDCs) grew by only 1.8 percent per year in real terms, i.e., a lower growth rate. Industry (including their FFRDCs) grew at a remarkable rate of 6.2 percent in real terms, as if to make up for lost time in the earlier period. Federal intramural performance, in contrast, experienced twice the rate of decline it had experienced earlier—a loss of 1.4 percent per year in real terms. Finally, nonprofit organizations (including their FFRDCs), were estimated to increase by only 1.1 percent per year in real terms from 1994–98.

According to preliminary estimates, these shifts in growth have led, in 1998, to academia (including FFRDCs) representing 14.1 percent of total U.S. R&D performance, Federal intramural activities 7.7 percent, other nonprofit

organizations (including FFRDCs) 3.1 percent, and private industry (including FFRDCs) 75.1 percent (table 5).

INDUSTRY

By preliminary estimates, R&D performance by private industry reached \$165.7 billion in 1998, including \$2.4 billion spent by FFRDCs administered by industrial firms. This total represents a 6.5-percent increase over the 1997 preliminary total in real terms (figure 11). That 1997 total of \$152.7 billion reflects a smaller, though still notable, real gain of 3.5 percent over 1996.

In 1998, R&D performed by industry that was not federally financed rose 7.7 percent in real terms above its 1997 level, according to preliminary data. Overall, these data imply that private companies (excluding industry-administered FFRDCs) funded 86.2 percent (\$140.8 billion) of their 1998 R&D performance, with the Federal Government funding nearly all the rest (\$22.5 billion, or 13.8 percent of total). Preliminary figures also indicate little or no change, in real terms, in Federal funds for these industrial R&D activities between 1997 and 1998. As recently as 1987, the Federal funding share of industry's performance total (excluding FFRDCs) was 31.9 percent; however, the Federal share of industry's performance has been steadily declining since its peak of 56.7 percent reached in 1959.

Individual industries show very different R&D performance trends and shares of the industry R&D total since the early eighties. R&D performance by aircraft manufacturers and spacecraft/guided missiles manufacturers (SIC codes 372 & 376, respectively) has been the most volatile, representing, for example, 25 percent of total industry R&D performance in 1988, but only 11 percent in 1996 (table 6). These movements can be explained, in part, by parallel shifts in Federal defense-related funding during the period.

The industrial sector that appears to have undergone the fastest growth in non-federally funded R&D is lumber, wood products, and furniture, which increased its own R&D expenditures from \$144 million in 1986 to \$634 million in 1996, reflecting a real annual growth in

Table 5. Projected levels of intersectoral transfers of funds for performance of R&D: 1998

Character of work/ sources of funds	Performer						Percent distribution by sources
	Federal Government	Industry 1/	Universities and colleges	U&C associated FFRDCs 2/	Other nonprofit institutions 1/	Total	
	[Millions of current dollars]						
Total R&D							
Federal Government.....	16,936	24,899	15,247	5,529	4,026	66,636	30.2
Industry.....	..	140,847	1,829	..	1,038	143,714	65.1
Universities and colleges.....	..	..	6,819	..	..	6,819	3.1
Other nonprofit institutions.....	..	..	1,778	..	1,671	3,449	1.6
Total.....	16,936	165,746	25,672	5,529	6,735	220,617	100.0
Percent distribution, performers.....	7.7%	75.1%	11.6%	2.5%	3.1%	100.0%	
Basic research							
Federal Government.....	2,867	1,429	11,009	2,688	1,529	19,523	56.7
Industry.....	..	7,161	1,157	..	478	8,795	25.5
Universities and colleges.....	..	..	4,314	..	..	4,314	12.5
Other nonprofit institutions.....	..	..	1,125	..	668	1,793	5.2
Total.....	2,867	8,590	17,606	2,688	2,675	34,426	100.0
Percent distribution, performers.....	8.3%	25.0%	51.1%	7.8%	7.8%	100.0%	
Applied research							
Federal Government.....	5,135	4,075	3,024	1,562	1,116	14,911	30.0
Industry.....	..	30,748	551	..	353	31,652	63.6
Universities and colleges.....	..	..	2,054	..	..	2,054	4.1
Other nonprofit institutions.....	..	..	535	..	602	1,137	2.3
Total.....	5,135	34,823	6,164	1,562	2,071	49,753	100.0
Percent distribution, performers.....	10.3%	70.0%	12.4%	3.1%	4.2%	100.0%	
Development							
Federal Government.....	8,934	19,395	1,213	1,279	1,381	32,202	23.6
Industry.....	..	102,939	121	..	208	103,268	75.7
Universities and colleges.....	..	..	451	..	..	451	0.3
Other nonprofit institutions.....	..	..	118	..	401	519	0.4
Total.....	8,934	122,334	1,902	1,279	1,990	136,438	100.0
Percent distribution, performers.....	6.5%	89.7%	1.4%	0.9%	1.5%	100.0%	

1/ Expenditures for FFRDCs administered by both industry and nonprofit institutions are included in the totals of their respective sectors. They are estimated to account for less than 2 percent and 12 percent, respectively, of the industry and nonprofit institutions performance totals. FFRDCs are organizations exclusively or substantially financed by the Federal Government to meet a particular requirement or to provide major facilities for research and training purposes.

2/ FFRDCs administered by individual universities and colleges and by university consortia.

KEY: FFRDC = Federally funded research and development center

NOTE: State and local government funds are included in industry funds reported to industry performers, and in university and college funds reported to university and college performers. Detail may not add to totals due to rounding.

SOURCE: National Science Foundation/Division of Science Resources Studies, appendix tables B-1, B-2, B-3 and B-4.

**Table 6. Industrial R&D performance, by type of industry:
1984, 1988, 1992, and 1996**

Industry	Year			
	1984	1988	1992	1996
	[Millions of current dollars]			
Total industrial R&D performance	74,800	97,015	119,110	144,667
	[Percent]			
Distribution by industry				
Drugs and medicines (283).....	4	5	7	7
Industrial and other chemical (28, excluding 283).....	6	6	6	6
Petroleum refining and extraction (13, 29).....	3	2	2	1
Machinery and computers (35)....	14	13	13	9
Electrical equipment (36).....	18	15	11	16
Aircraft and missiles (372, 376).....	25	25	14	11
Other transportation (37, excluding 372, 376).....	10	11	9	11
Professional and scientific instruments (38).....	6	6	8	8
Other manufacturing industries....	7	6	6	8
Nonmanufacturing industries.....	7	11	24	23

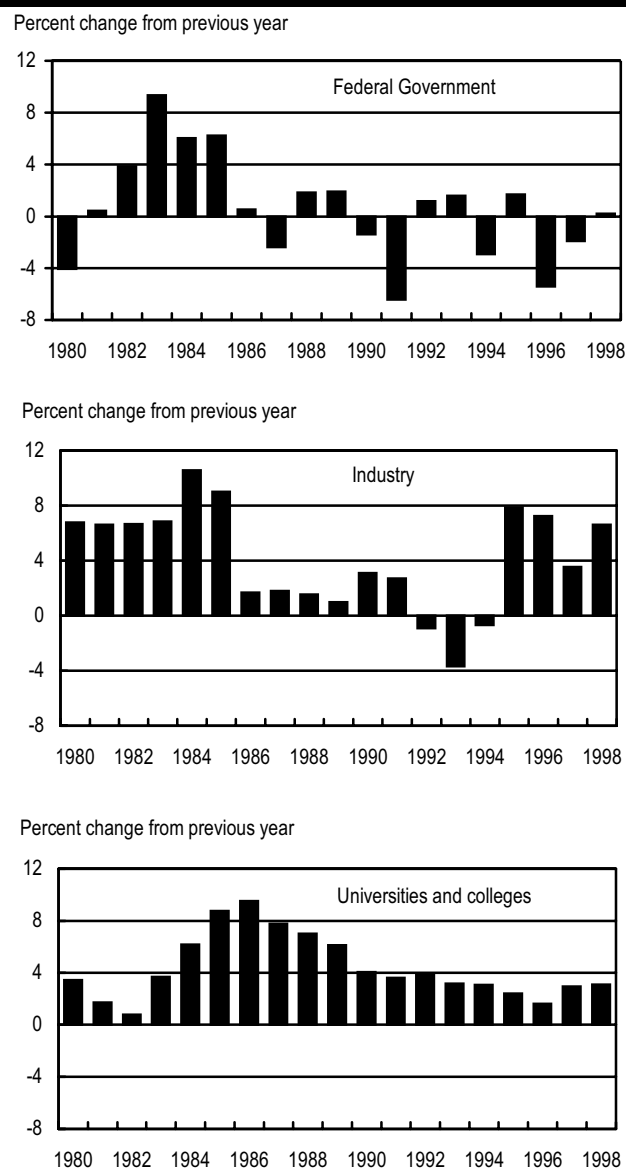
NOTE: Numbers in parentheses are SIC codes. As a result of changes in the underlying survey design, data for 1992 and 1996 are not directly comparable with those for earlier years. See accompanying text and appendix A.

SOURCE: National Science Foundation/Division of Science Resources Studies, table B-16 and *National Patterns of R&D Resources 1996*, NSF 96-333, table C-26.

R&D of 12.4 percent.²⁰ (See table 4.) However, this finding should be read cautiously, especially in view of the fact that there was relatively little R&D in the industry to begin with, making it easy for a high growth rate to be achieved without necessarily reflecting inherent aspects of the industry that would favor new R&D. The same caution might also be advised in the interpretation of R&D growth for the paper and allied products industry, which rose substantially from \$538 million in 1986 to \$1,534 million in 1996, reflecting the second-highest real growth, among the industrial categories examined, of 7.6 percent.

²⁰ Although they had the highest R&D growth rates, the sectors “other manufacturing industries” and “other nonmanufacturing industries” are not entered into this discussion for two reasons: First, as noted in table 4, their definitions (i.e., what firms they include) have changed over the course of the time period in question, making it inappropriate to interpret their growth as a true change in their economic resources devoted to R&D. Furthermore, their definitions, even at a single point in time, are obscure, as each they represent an enormous variety of activities. Consequently, any observation of their R&D growth would offer little understanding of how or why such growth occurred.

**Figure 11. Changes in national R&D spending,
by performer: 1980–98 (based on
constant 1992 dollars)**



NOTE: Data are preliminary for 1997 and 1998.

SOURCE: National Science Foundation/Division of Science Resources Studies, table B-1A.

Industries with at least \$1 billion in R&D in 1986 would be expected, on average, to have growth rates in R&D that are less subject to chance (i.e., less subject to circumstances unrelated to the potential effectiveness of their R&D). Among these seven industries, excluding the more obscure categories of “other manufacturing industries” and “nonmanufacturing industries,” electrical equipment (which includes computer chips for example) had the highest real annual growth rate of 4.3 percent. It is followed by chemicals and allied products (4.0 percent), professional and scientific instruments (2.4 percent), and

transportation equipment (including aircraft and missiles) (1.0 percent). Machinery, which includes computer and office equipment, experienced a real reduction in R&D of -0.9 percent per year between 1986 and 1996, although this is largely explained by the reclassification of several major R&D performing firms from this industry in 1986 to computer software (SIC 737) in 1996. Also experiencing reductions in real R&D were food, kindred, and tobacco products (-1.1 percent) and petroleum refining and extraction (-4.9 percent).

Federal financing for industrial R&D, including industry FFRDCs, has varied markedly across both time and different industries. The Federal Government provided \$23.7 billion for industry R&D in 1996, the most recent year for which detailed data by industrial category are available. Aerospace companies (or the industrial sector “aircraft and missiles”) alone received 44 percent of all Federal R&D funds provided to all industries. Consequently, 65 percent of the aerospace industry’s R&D dollars came from Federal sources, while the remaining 35 percent came from companies’ own funds (figure 12). In comparison, the drugs and medicines sector in 1996 financed 100 percent of its R&D from company funds; machinery 99 percent; professional and scientific instruments 68 percent, transportation equipment other than aircraft and missiles 90 percent, business services 97 percent, and engineering and management services 62 percent.²¹

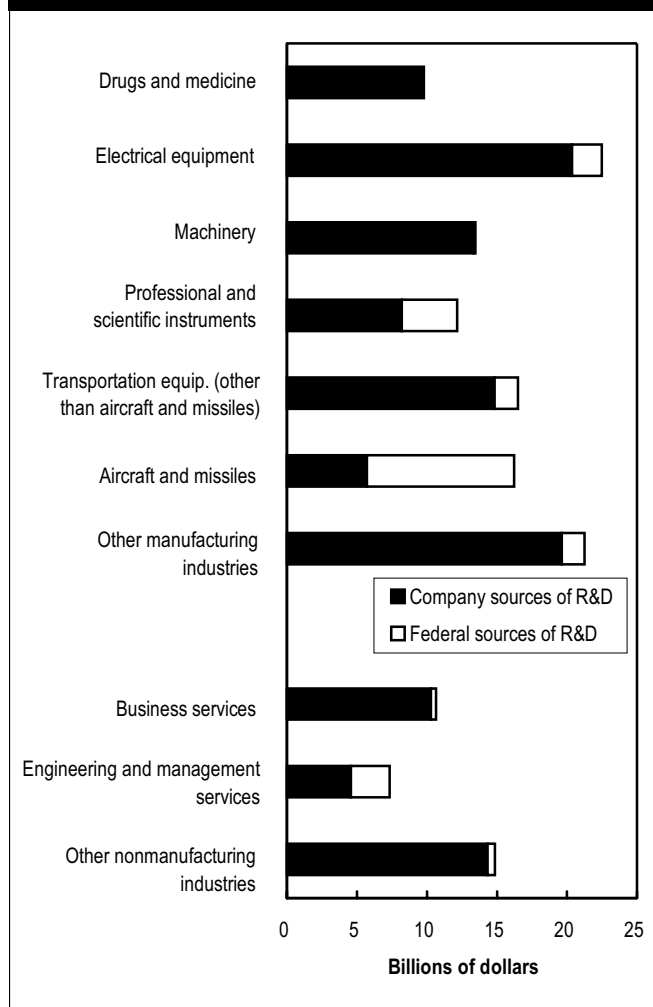
FEDERAL GOVERNMENT

The Federal Government, excluding FFRDCs, will perform \$16.9 billion of the total 1998 U.S. R&D in 1998, based on preliminary estimates. This figure is slightly higher than the level estimated for 1997, \$16.6 billion, which reflects only 0.2-percent growth after adjusting for inflation. Federal agencies account for 7.7 percent of the projected 1998 national R&D performance effort, continuing the trend begun in 1972, in the gradual decline of Federal performance as a percent of total R&D.

The Department of Defense (DoD) continues to perform more Federal intramural R&D than any other Federal agency; in fact, it performs more than twice the R&D of the next-largest R&D-performing agency, the Department of Health and Human Services (HHS)

²¹ The 100 percent company funding for the drugs and medicines sector does not include the indirect support for R&D that NIH ultimately provides to this sector.

Figure 12. Industrial R&D performance, by industry and source of funds: 1996



SOURCE: National Science Foundation/Division of Science Resources Studies, table B-21.

(whose intramural R&D is performed by the National Institutes of Health) (table 3). However, according to preliminary tabulations, DoD’s intramural R&D performance declined substantially between FYs 1997 and 1998, down 12.9 percent in real terms, to a projected FY 1998 level of \$7.7 billion. Furthermore, an undetermined amount of DoD’s intramural R&D ultimately appears to be contracted out to other extramural performers. NASA’s intramural R&D grew slightly, by 1.2 percent in real terms by preliminary FY 1998 estimates, to \$2.3 billion, while the HHS rose by only 0.5 percent in real terms, to \$2.9 billion.²² Together, these three agencies account for

²² This increase represents the overall effect on intramural R&D for the agency, which takes into account the Social Security Administration (SSA) becoming a separate agency from HHS during fiscal year 1995. That is, the percent increase reported would be larger, though negligibly, if HHS in 1995 were defined as not including SSA, as it is in 1996.

76.1 percent of the total (\$16.8 billion), estimated Federal intramural R&D for FY 1998 (table 3).

Total R&D performed by industrial, academic, and nonprofit FFRDCs, combined, is expected to reach \$8.8 billion in 1998, which is essentially the same as its preliminary level of \$8.6 billion in 1997, after adjusting for inflation. R&D at FFRDCs account for 4.0 percent of the national R&D effort, most of which (\$5.5 billion in 1998) is accounted for by university and college administered FFRDCs.

Until 1979, the Federal Government had been the second-largest R&D performer in the Nation after the industrial sector. Its share of the national R&D performance total, however, fell from 16 percent in 1970 to 12 percent in 1980. This reduction was due primarily to cutbacks in space R&D programs: NASA funds for intramural R&D performance were reduced by more than one-half in real terms during this period. As a result, in 1979 the academic sector—including associated FFRDCs—surpassed the Federal Government in terms of its share of national R&D performance.

UNIVERSITIES AND COLLEGES

Universities and colleges (excluding academically-administered FFRDCs, which are discussed separately below) are expected to account for 11.6 percent (\$25.7 billion) of the 1998 national R&D performance effort. This total implies that they have experienced moderate, real growth of R&D by 3.1 percent from the year before.

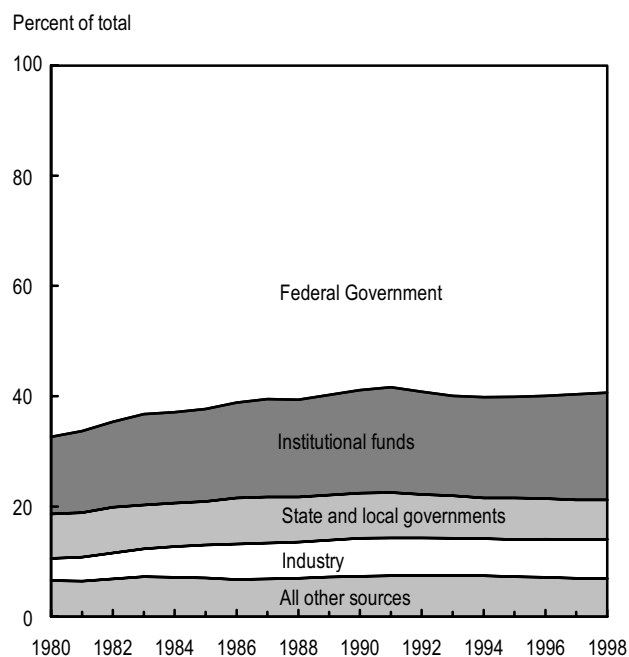
Unlike the industry and Federal sectors, the academic sector's overall R&D performance increased rapidly throughout the mid-1980s and continued to grow, though less rapidly, in the early 1990s (figure 11).²³ From 1980–85, real growth averaged 4.2 percent annually. Whereas real increases in the R&D performance of other sectors slowed considerably in the period from 1985–94, universities and colleges experienced a 5.3-percent real, annual growth. Finally, from 1994–98, by preliminary estimates, R&D performed in academia slowed, growing at a real rate of 2.5 percent per year.

²³ These academic R&D data are for separately budgeted expenditures only. Consequently, they exclude that portion of salaries for research time or other research expenses financed by funds not specifically earmarked for R&D from state and local governments and other non-federal sources, including endowments.

The Federal Government has long provided the largest share of the R&D funds used by universities and colleges. In the early 1980s, Federal funds accounted for roughly two-thirds of the academic total. By 1991, however, this share had dropped to a low of 58 percent and has remained between 59 and 60 percent since then (figure 13).

Between 1985 and 1994, the academic share of total U.S. R&D performance grew from 8.7 percent to 12.7. By 1994, federally financed academic R&D (\$12.8 billion) had grown by 4.9 percent per year in real terms since 1985, and university and college R&D performance using non-federal funds (\$8.4 billion in 1994), had grown by 6.0 percent in real terms. During this period, the links between academic and industrial R&D had expanded considerably. Industry's academic R&D funding increased by 6.7 percent per year in real terms from 1985–94, although in 1994 it accounted for just 6.7 percent (\$1.4 billion) of academia's 1994 R&D total (excluding FFRDCs). Universities' own institutional funds—the largest non-federal source—had grown by 6.3 percent per year in real terms between 1985 and 1994, and by 1994 accounted for 18.3 percent (\$3.9 billion) of their

Figure 13. University and college R&D performance, by source of funds: 1980–98



NOTES: State and local government funds exclude general purpose appropriations that universities use at their discretion for R&D. Such funds are included in the institutional funds total.

SOURCE: National Science Foundation/Division of Science Resources Studies, table B-1A.

total R&D expenditures. Real R&D funds from state and local governments grew by 4.5 percent per year in real terms over this period, and by 1994 represented 7.4 percent (\$1.6 billion) of academic R&D.

In the period 1994–98, by preliminary tabulations, the academic share of total U.S. R&D had dropped from 12.7 to 11.6 percent. Federal funds for academic R&D (excluding FFRDCs) had grown in real terms by 2.2 percent per year to a preliminary level of \$15.2 billion. Non-federal funds for academic R&D grew by 3.0 percent, to \$10.4 billion. Among these non-federal funds, industry's contribution to academic R&D rose in real terms by 4.1 percent per year, to \$1.8 billion in 1998 by preliminary estimates, while universities' own funds rose by 4.0 percent per year in real terms, to \$5.0 billion in 1998. R&D funding from state and local governments for academic R&D performance grew by 1.8 percent per year in real terms, to \$1.8 billion by 1998 according to preliminary tabulations. As a result, the shares of funding to academic R&D in 1998 were estimated to be 59.4 percent from the Federal Government, 7.2 percent from state and local governments, 7.1 percent from industry, 19.4 percent from universities' own funds, and 6.9 percent from nonprofit organizations.

The most recent year for data on university R&D expenditure by field of study is for FY 1996 (appendix table B-24). In this fiscal year, life sciences accounted for 55.2 percent of academic R&D expenditures, engineering accounted for 16.0 percent, and the physical sciences (astronomy, chemistry, physics, and related subfields) accounted for 9.8 percent. These percentages have changed little in recent years—in FY 1989, for example, life sciences accounted for 53.8 percent, engineering for 16.0 percent, and the physical sciences 11.0 percent.

ACADEMICALLY ADMINISTERED FFRDCs

R&D performance in 1998 by university-administered FFRDCs is estimated to be \$5.5 billion, or approximately 2.5 percent of the national R&D effort. These FFRDCs account for 17.7 percent of the total 1998 academic (universities and colleges plus academically administered FFRDCs) R&D performance.

From 1974–80, R&D at academically administered FFRDCs grew by 8.6 percent per year in real terms. This increase largely mirrored the Federal emphasis on energy programs. Since 1980, the Federal shift away from energy concerns has resulted in much slower growth in academically administered FFRDC R&D performance—only 1.3 percent per year in real terms.

The distribution of R&D by field at university-administered FFRDCs has been quite different from the distribution of R&D at universities and colleges. In FY 1996, engineering accounted for 34.7 percent of R&D expenditures at university-administered FFRDCs (in contrast to 16.0 percent at universities and colleges), physical sciences 40.1 percent (in contrast to 9.8 percent), and life sciences 2.3 percent (in contrast to 55.2 percent). (See appendix tables B-24 and B-26.) However, like R&D at universities and colleges, these percentages have changed little in recent years—in FY 1989 engineering at university-administered FFRDCs accounted for 34.7 percent, the physical sciences 38.6 percent, and life sciences 2.8 percent.